

HISTORY OF LUNG DISEASES OF COAL MINERS IN GREAT BRITAIN: PART I, 1800-1875

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"To the advancement of all the inductive sciences, a knowledge has been necessary as well of the position of the particular science at the moment of investigation, as of the steps by which that position had been obtained; this in turn, tending to throw light on the direction in which future progress might be expected."

Since 1930 pneumoconiosis of coal miners has constituted a major medical and social problem in Great Britain, particularly in South Wales. The intervening years have been marked by considerable research into the aetiology, early diagnosis, significance, incidence and control of the disease, and in this work the investigators have been greatly assisted by the advanced techniques of modern pathology, physiology, biochemistry, chest radiology, dust-sampling, and dust-analysis.

It is remarkable that it was almost precisely a century earlier when the problem attracted similar urgent attention, but on that occasion the focus was on the Scottish coal-field. By contrast, the physicians of those days were dependent almost entirely on the correlation of clinical observations with morbid anatomical changes observed at post-mortem inspections.

The purpose of this communication is to review the knowledge of miners' lung diseases as recorded 100 years ago, so that we may assess just how far our knowledge of these diseases has advanced in the interval.

General Background

While, in the main, our concern is with the medical aspects of the subject, appreciation of the problem will be enhanced by considering the more general aspects of coal-mining, particularly as they existed in the first 50 years of the nineteenth century.

According to Bremner (1869) the earliest documents in which coal-mining in Great Britain is mentioned are "The Saxon Chronicle of Peterborough" written in the year 852, and Bishop Pudsey's "Boldon Book" dated 1180. Newcastle coal is first alluded to in a charter granted to the

inhabitants of that town in 1234, and the first mention of coal in Scotland occurs in a charter granted in 1291 to the Abbot and Convent of Dunfermline, but the earliest workers of the mineral are supposed to have been the monks of Newbattle Abbey. As might be expected, the earliest workings were confined to outcrops occurring along the banks of rivers. Underground working at any considerable depth had to await the development of efficient methods of ventilation and pumping of water. The real impetus to coal production was associated with the manufacture of iron and derived from the development of the steam engine in the early part of the eighteenth century. Savery's original steam-pumping engine was made in 1698, and Newcomen's improved model was constructed in 1705, but it was not until 1762 that a steam engine was first used to work a coal pit in Scotland. By the beginning of the nineteenth century, the period with which we are concerned here, coal-mining was a large and expanding industry. It is estimated that by 1839 Britain was producing 36,000,000 tons of coal. Official statistics, however, were not published until 1854 when output was recorded as 64,500,000 tons. Twelve years later, in 1866, production reached 100,728,881 tons, and the number of men employed was 320,663 (Bremner, 1869).

In Scotland at this date the great coal-fields occupied a well-defined position extending across the country in the line of the valleys of the Forth and Clyde and involving a superficial area estimated at 1,750 square miles. This area was divided into two districts: the eastern district, including the Lothians, Fifeshire, Clackmannanshire, Kinross-shire, part of Perthshire, the eastern district of Stirlingshire and the upper division of Lanarkshire ;

and the western district, including the lower division of Lanarkshire, the western division of Stirlingshire, the counties of Ayr, Dumbarton, Renfrew, Dumfries, and Argyll.

The following table gives a concise picture of the industry in Scotland about that time :—

STATISTICS OF COAL-MINING IN SCOTLAND FOR THE YEAR 1866

District	Number of Collieries	Number of Miners	Tons of Coal Raised
Eastern ..	254	21,200	6,100,000
Western ..	218	20,046	5,934,638
Total ..	472	41,246	12,034,638

At the present time, 1951, in Scotland, the number of miners employed and the output of coal are almost precisely double these figures.

Employment in Coal Mines

The First Report of the Commissioners on Children's Employment in Mines (H.M.S.O., 1842) provides abundant detailed information.

Mining work was not restricted to adult men but included women and very young children of both sexes : " It is more common for Children to begin work in the collieries in the East of Scotland at five and six years of age than in any part of England ". Apparently this custom was established by the colliers themselves, for the mining overseer at Edgehead Colliery reported :

" I have been underground overseer in these mines eight years and have witnessed with regret the early ages colliers take their children below ground. The masters have no control over the colliers ; or rather, they never interfere with the customs of the colliers themselves. Children of seven and eight years of age are repeatedly taken below and then all hope of instruction ends."

As to the length of time spent in underground work the Commissioners report :

" There is overwhelming evidence that the labour of the coalpits in this district (East of Scotland) is often continued, on alternate days, at least for 15, 16, 17 and even 18 hours out of the 24, and great numbers of Children and Young Persons state that 14 hours is the regular and ordinary time during which they daily work in the pits."

But it is further commented :

" The hours of work in collieries are evidently too long, for it is found impossible for men to continue them day after day, and the general custom among colliers is not to exceed ten days' work in the fortnight. This is the amount of work stipulated by the regulations of collieries."

Ventilation of underground workings was poor, and not infrequently the air was insufficient to

sustain the hard physical labour and on occasions even to support the combustion of lamps or candles. The general atmosphere was vitiated with carburetted hydrogen, carbonic acid gas, the fumes of gunpowder, and the smoke of oil lamps or tallow candles.

These very briefly are the circumstances of work as they existed in the collieries and against which we may now proceed to study the occurrence of respiratory diseases as recorded among the coal miners at that period.

Melanosis of the Lungs

Early in the nineteenth century the pathological anatomists of Paris directed attention to " a peculiar form of animal production ", which they named melanosis (Thomson, 1837).

In 1806 Laënnec delivered to the Faculty of Medicine of Paris a memoir on melanosis of the lung, of which he distinguished four types : (1) melanosis in which the masses are enclosed in cysts ; (2) melanosis in which the masses are not encysted ; (3) melanosis in which the black matter infiltrates the substance of the lung ; and (4) melanosis in which the black matter is deposited on the surface of the lung.

Later in his classical treatise on mediate auscultation (1837), he reviewed and discussed the whole subject. Laënnec quite clearly recognized that true melanosis was a form of cancer and readily distinguishable from the black coloration of the lungs, which he had observed to occur in adult life and which became more pronounced with the advance of age. Coal miners' lungs, in his experience, were characterized by the deposition of "*la matière noire pulmonaire*" and in some cases he had found at necropsy masses resembling "*un morceau de savon noir*". In his opinion Bayle had sometimes failed to distinguish between melanosis and black pulmonary matter.

Meanwhile in 1815 Bayle had recorded his observations on the subject based on 900 necropsies in phthisis cases, which had come under his notice in the Hôpital de la Charité in Paris (Bayle, trans. by Barrow, 1815). Among his more interesting comments are the following :

" Phthisis with melanosis is frequently of long duration and commonly, for a considerable time, does not shew any alarming symptom. All persons affected with this species of phthisis have attained an advanced age, rarely less than 50 years. When the disease is quite single they do not suffer much in the chest."

and later :

" Phthisis with Melanosis appears to be that which commonly lasts longest ; but of those in whom the Phthisis lasts a great many years some are affected with tubercular Phthisis. There are then but few

tubercles, and the ulcerations produced by the tubercles seem to form a purely local disease which does not affect the vital function". . . .

"They are often subject, during the last months of their disease, to an oedema of the legs, which frightens them much, though it commonly gives way easily."

From a series of necropsies, of which some details are given, it is clear that he was dealing mainly with chronic fibroid tuberculosis of the lungs and nowhere does he suggest that the disease is related to occupation.

The first English contribution to the subject occurs in a paper entitled, "On the Colouring Matter of the Black Bronchial Glands and of the Black Spots of the Lungs", by Dr. George Pearson, F.R.S. (Pearson, 1813). In the course of many post-mortem inspections Pearson had carefully investigated the conditions of the lungs in babies, adolescents, and adults and had noted that "at the age of about twenty years the lungs have a mottled or marbled appearance from black and dark blue spots, lines and points disseminated under the transparent pleura". By the age of 65 onwards the lungs appeared almost uniformly black due to "the number and congeries, or coalescence of the maculae, points and lines just mentioned". Following experiments in which he subjected portions of lung, pleura and bronchial glands to a variety of physical and chemical agents he formed the opinion that the black matter was due to "animal charcoal in the uncombined state", the origin of which he ascribed thus :

"I think the charcoal, in the pulmonary organs, is introduced with the air in breathing. In the air it is suspended in *invisibly small particles*, derived from the burning of coal, wood and other inflammable materials in common life."

As to the location and distribution of the black matter in the lungs, he then proceeds to make the following interesting judgments :

"When I compared the black lines and the black net-like figures, many of them pentagonal, on the surface of the lungs, with the plates of the lymphatic vessels by Cruikshank, Mascagni and Fyffe, I found an exact resemblance. And when I found that the vessels contained charcoal, I judged that it was fair to infer that the lymphatics of the lungs absorb a variety of very different substances, and especially this coaly matter, which they convey to the bronchial glands, and thus render them of a black or dark blue colour."

From the occurrence of the condition in the lungs of country dwellers he concluded that the sooty matter was more extensively diffused through the atmosphere than was generally apprehended, and he explained the absence of the same condition in brute animals as being due to the natural short period of their life. In a case observed in a man

aged 42 years he attributed the condition to his being "a smoker of tobacco".

From the foregoing it would appear that Pearson was recording the natural pigmentation of the lungs which develops in varying degree in the general adult population.

The next recorded reference to black lung occurs in relation to a post-mortem examination made at the Royal Dispensary, Edinburgh, during the year 1824-25. Dr. Carswell described this case in an article on melanosis in the *Cyclopaedia of Practical Medicine* and expressed the opinion that the appearances observed were similar to those in Dr. Gregory's case, details of which appear next. The occupation of the workman was not stated. During life the case was regarded as "emphysema consequent upon chronic catarrh", and the poor patient ultimately died "universally anasarcaous". At the inspection it was observed that "the whole of both lungs were perfectly black; in many parts indurated and oedematous; in others softened and excavated. There were no tubercles, nor was there any similar discolouration in any part of the body".

As will appear later (Thomson, 1837), this peculiar discoloration of the lungs continued from about this time (1824) to be a matter of regular observation and conjecture by doctors throughout the coal-mining districts of the east and west of Scotland. In their discussions, however, they did not specifically relate the condition to occupation. No further publication on the subject was made until 1831 when Gregory published his "Case of Peculiar Black Infiltration of the Lungs resembling Melanosis", and he is the first author to record in print that the disease arises out of employment in coal mines.

The title itself is of interest and the author's introductory remarks are significant :

"I am induced to publish the following case, partly because I have not hitherto met with the record of any similar affection; and partly with a view of calling the attention of these practitioners who reside in the vicinity of the great coal-mines, and who may have charge of the health of miners, to the existence of a disease, to which that numerous class of the community would appear to be peculiarly exposed."

The case was a man aged 59 years who, after having served his time as a regular soldier, was employed for 10 or 12 years as a collier at Dalkeith. On admission to hospital on March 29, 1831, on account of general anasarca, he stated that he had been unable to work during the previous 16 months. Death from progressive heart failure occurred three weeks later.

At necropsy the lungs were universally adherent to the chest wall; the pleura was thickened and in places ossified. "When cut into, both lungs

presented one uniform black carbonaceous colour, pervading every part of their substance". The appearances of the left lung are of particular interest.

"The left lung did not appear to contain any cavities, but was condensed, and loaded with black serum. Some minute hard points could be felt in various parts of both lungs, but they did not differ at all in colour from the surrounding substance; and no distinct tubercular deposition or infiltration could be detected in those portions of the lungs which were most hepatized, even with the aid of the microscope. The texture in these parts appeared quite uniform, and the minute hard points felt in other parts rather conveyed the impression of their being merely the ends of small bronchial branches divided in making the section. The bronchial glands did not appear enlarged, but partook of the same black colour as the substance of the lungs."

Gregory then proceeds with the following commentary:

"The question here immediately presented itself, whether this ought to be considered as a case of infiltration of the substance of the lungs by the peculiar black matter of melanosis?—or whether the black colour of these organs depended merely upon the habitual inhalation of a quantity of the coal-dust with which the atmosphere of a coal-mine must be constantly charged, and which, remaining unabsorbed and acting as a foreign body, had led ultimately to disorganization of the pulmonary tissue? in like manner as one form of phthisis is found to be particularly prevalent among those who by their occupations are most exposed to the inhalation of small irritating particles, such as stone-cutters, millers and needle-grinders."

He submitted representative portions of the tissues to Dr. Christison who, after various tests, reported that the black matter, which he found in the lungs, was entirely different from melanosis. This accorded with Gregory's own opinion which was based on the morbid anatomical appearances. Thus it was appreciated that there was a distinction between this black infiltration and melanosis, and, further, that the condition occurred as an occupational risk of coal miners and was possibly due to the inhalation of coal dust.

These opinions on aetiology, pathology, and occupational risk seem to have gained an almost immediate measure of acceptance, for just two years later Dr. William Marshall of Cambuslang, near Glasgow (Marshall, 1833, 1834), published two articles on "Cases of Spurious Melanosis of the Lungs or of Phthisis Melanotica". Three cases are presented, all men who had worked as coal miners from boyhood, and who died, respectively, at the ages of 58, 62, and 57 years. In each instance the workman had suffered chest symptoms for many years, which symptoms the men themselves had attributed to bad air in the mines. During the latter

part of the illness two of the patients expectorated sputum "changed to deep black colour like printer's ink". The third case was noteworthy in so far as the spit was at no time black. In the necropsy reports the lungs are described as "coal black" or of "a jet-black colour throughout like lamp-black".

Marshall evidently considered the value of this black spit as an aid to early diagnosis, for he writes:

"There can be little doubt that the black matter does not appear in the expectoration until the substance of the lung begins to break up; that the black expectoration, in fact, marks the stage of commencing excavation, and that it increases in quantity as the destruction of the lung advances."

In reviewing the various post-mortem inspections which he had witnessed he records that the lungs presented four different conditions of the substance of the lung, which may be presumed to mark so many consecutive stages of the disease: (1) the lung deeply stained with the melanotic deposit, yet soft, crepitous; (2) a similar condition of the lung but scattered through it hepatized nodules of greater or less bulk, these characterized by their greater resistance to the knife; (3) these hepatized areas accompanied by vomicae in various stages; and (4) general excavation of the lung.

Various opinions were at that time held as to the causation of the disease but in the main it was attributed either to the effects of blasting with gunpowder, or to the inhalation of lamp-black or soot from the oil lamps of the miners. Marshall rejected the first, as gunpowder was not used at the coal-wall in the local mines, but was restricted to driving stone-mines. Similarly he rejected the second explanation, as lamps were in use at all the mines, whereas his cases were derived from only two of these mines, so he concluded:

"The true explanation of the origin of this disease in colliers seems to be, that it is in consequence of the inhalation of fine coal dust, and its deposition in the substance of the lung. That coal may float through the air in particles sufficiently fine to be inhaled without immediate irritation and that it is thus inhaled is a matter of common observation."

He further considered that the lungs are able to deal with certain quantities of coal dust but men "if diseased or otherwise cannot cope with the quantity, contract a noxious stage". As to the varying incidence of the condition among colliers from different mines, he observes that mines differ in degree of dustiness and wetness. Accordingly conditions favourable to disease occur in "mines which have hard dry seams and where there is much pick work".

As to the comparative rareness of the disease among the men he considers there is an "individual predisposition".

In support of his contention that the dust is the noxious factor, he cites a case of an iron-moulder, who used charcoal in dusting the moulds.

These two articles were the subject of a critical letter addressed to the Editor of the *Lancet* by Matthew Gibson, surgeon, of Govan Haugh, Glasgow (Gibson, 1834): "In my humble opinion these cases are not melanosis of the lungs, but rather pure simple every-day phthisis. . . . I do not consider the black expectoration to be a disease but quite the contrary".

In support of his submission he cites cases under his care. He admits its prevalence in colliers and among others like millers, who are similarly exposed to dust in their occupations.

In the year 1834 Dr. G. Hamilton, of Falkirk, presented to the Edinburgh Medical Society a case of "Melanotic Infiltration of the Lungs with Old and Recent Pleuritis". The patient, who died of progressive heart failure, was aged 58 years, and for 40 years he had been employed as a moulder at Carron iron works. At necropsy the lungs were observed to be "universally pervaded with black matter which had collected in dense masses particularly in the upper portions; it was as if they had been infiltrated with soot or finely powdered charcoal but nothing like tubercular matter was present". Portions of the indurated lung were sent to Dr. Graham, F.R.S.E., lecturer in chemistry in the Andersonian Institution, Glasgow. The material was digested in hot nitric acid and then dried to powder whereby it was found that one quarter of the dry residue was composed of carbon. As a control experiment, coal and charcoal were treated by the same methods. Dr. Graham concludes:

"The carbonaceous matter of the lung cannot therefore be supposed to be coal altered by the different chemical processes to which it has been submitted in separating it from the animal matter of the lung. The carbonaceous matter from this lung appears rather to be lamp-black. . . . It is obvious, therefore, that this is another case of spurious melanosis, as previously observed in colliers."

The carbon represented the finely powdered charcoal as used by moulders in their occupation. This was confirmed by Dr. Girdwood, a local Carron practitioner, who described the clinical features of two similar cases under his care.

Later in the same year (1834), Dr. Graham reviewed his observations on morbid material from cases referred to him. These are his conclusions.

"(1) The black matter found in the lungs is not a secretion but comes from without.

"(2) This foreign matter probably varies in composition in different lungs, but in the cases examined seems to be little else than lamp-black or soot.

"(3) It is evident that the accumulation of charcoal in the lungs, which Dr. Pearson remarks to occur

more or less in every subject, may proceed in peculiar circumstances to a great extent without affecting immediately the general health of the patient."

Dr. William Craig of Glasgow, who as part of his practice attended many patients in the city's Poor Law hospitals, thereupon communicated in a letter to Professor Graham his personal "Observations on Spurious Melanosis". Some of these merit quotation in full.

"I believe that in all extreme cases of spurious melanosis which have occurred in colliers and moulders, there must have existed some previous disease of the lungs, which prevented the foreign substances from being thrown off. May not a tuberculated or excavated state of the lung favour the retention of the black matter?"

In recent times the contributions of Gough (Gough and Wentworth, 1946) to the pathology of coal miners' pneumoconiosis are acknowledged as outstanding. The large tissue sections of lungs have focused attention on the coal nodules and the associated focal emphysema. This being so, Craig's observations published in 1834 are of more than passing interest.

"It is only in the case of colliers, moulders or others who inhale large quantities of black matter, that the lungs are rendered perfectly solid. The best manner of ascertaining the exact situation of the black matter in such cases is by inflating the lung slightly, drying it thoroughly, and then cutting it into slices in various directions. When a lung is prepared in this manner, the air cells can be distinctly seen with the naked eye, and by means of a small magnifier the exact situation of the black matter may be easily ascertained."

He continues:

"I have in my possession a specimen of an entire dried emphysematous lung, which shows very distinctly, in consequence of the dilated state of its air-cells, the situation of the black matter. As I look upon this preparation as very valuable on this account, I will attempt to give you a description of it. Its pleural surface presents a grayish or mottled appearance, in consequence of a mixture of the black matter with the dilated air-cells. The interlobular lines contain a considerable quantity of black matter. Dilated air-cells, varying from the size of a pea to that of a walnut, are seen on its surface. On making a vertical section of it, the cut surfaces present the usual appearance of an emphysematous lung. The air-cells are greatly dilated throughout its whole substance. Instead of being of their natural size, which is a little larger than a pin's point, they are generally of the size of a pea. Some are as large as to admit the point of the little finger. In some parts the cells, besides being simply dilated, are ruptured into one another, and present cavities varying from the size of a hazel nut to that of a walnut. In those cells which are simply dilated, the cavities are uniform, rounded and smooth on their inner surfaces; but in those in which rupture has taken place, the cavities are irregular in shape, and present delicate ragged portions stretching across them in various directions.

In some parts these portions have an arborescent appearance, being in all probability the remains of arteries.

"Let us now see in what manner the black matter is disposed in these dilated and ruptured air-cells. The cut surface of the lung presents an irregularly grayish or mottled appearance, in consequence of the black matter being more abundant in some parts than in others. In those parts where the air-cells are most dilated, the black matter is most abundant; and as all the cells are more or less dilated, the cut surface of the lung is darker than usual."

The subject of the above report was "a poor woman above ninety years of age, an inmate of the Poor's Hospital of this city".

Three years later, in 1837, Dr. Thomas Stratton of North Shields published a "Case of Anthracosis or Black Infiltration of the Lungs". The chief interest of this contribution is that for the first time the term anthracosis was applied to the disease in colliers. The generic term pneumonokoniosis was not invented by Zenker until 1866, and in 1874 Proust introduced the shorter form in writing of anthracosis or pneumoconiosis anthracosica. The next stage is marked by the classic contributions to the literature in 1837 and 1838 by Thomson of Edinburgh. These articles represent the experience and observations of the author and his father beginning with attendance at a post-mortem examination conducted at the Royal Dispensary, Edinburgh, in 1824. This appears to have excited their interest and thereupon they resolved to collect as much information on the subject as possible. To this end they enlisted the support of their medical friends, and among those who collaborated it is interesting to note the name of Dr. James Y. Simpson and many of those whose original contributions have already been noted.

The main inquiry was carried out in 1833 by means of a questionnaire which was addressed to doctors practising in colliery areas.

After a review of the existing literature Thomson proceeds to an analysis of the cases recorded in the communication. These are divisible into cases observed at necropsy, and sub-divided into those manifesting symptoms in life, and those without symptoms or signs, and clinical cases in which no necropsy was obtained.

Among the doctors who replied there is considerable diversity of opinion as to the occurrence, incidence, nature, and manifestations of the disease. Even so it is quite clear that their experience would approximate very closely to a similar inquiry carried out today. The tubercle bacillus was unknown to them but they clearly distinguished between phthisis and tubercular phthisis, between wasting in which the patient died "universally anasarous", and emaciation in which the patient died of a "hectic

consumption". Radiographic examination of the lungs was not available, but their observations and descriptions of pathological changes were minute and accurate and closely correlated with clinical manifestations and formed the basis of a classification into stages of disease. They recognized the nodulation in stone workers as opposed to the black crepitous lungs and massive agglomerations in the lungs of the men at the coal-wall. From necropsies on men killed in accidents they learned that universal black lung was compatible with health and full work. Certain excerpts from the replies are worthy of reproduction here.

Symptomatology

Dr. James Y. Simpson, reporting on a man aged 40 years, who had been employed for many years at Pencaitland colliery, near Tranent, as a coal-setter, that is "in removing the strata of sandstone and the beds and veins of secondary trap", records:

"He labours under a continual slight dyspnoea, which does not prevent him from taking gentle exercise but it is always aggravated to a great degree by any considerable exertion. The symptoms altogether approach more to those of asthma or of chronic mucous catarrh, than to those of tubercular phthisis."

In a second case of a man aged 60 years described by the same doctor:

"Though capable of taking a considerable degree of easy exercise on foot, and to external appearance rather a hale-looking old man, he has been perfectly unable to work in the pits, or at any employment for five years past, on account of a great want of breath. During the previous four or five years he had suffered much from dyspnoea, especially on going to the pit in the morning, the road being up-hill."

Dr. Marshall, reporting on a miner who had suffered for seven years from cough and dyspnoea aggravated in winter states that "the sputum became purulent and he had all the appearances of a person labouring under phthisis". The sputum is variously described as resembling printers' ink, black ink, china-ink or blacking or tinged with soot or coal-coom. Thomson himself observes:

"The black matter expectorated by colliers is of two kinds. One is simply the coal-dust inhaled while the individual is at work, and this is spit by every collier, the quantity varying according to the nature of the coal and the manner in which it is worked. The dust thus inhaled is never considered by the workman as at all dangerous, and is generally wholly expectorated in a few hours, or at most in a day or two after exposure. The miners are of opinion that eating largely of fresh butter facilitates its expectoration. The other kind of black matter is of a very different nature, being generated in the lungs themselves. When the disposition to produce it has been created, that disposition continues after the cause has been removed."

Clinical Signs

The following picture of a patient is striking :

"He has a considerable degree of the stoop or rounded curvature of the back which is so frequently seen in old asthmatics, and his sternum and ribs are projected forwards in the manner in which they are usually seen to be in such individuals."

Morbid Anatomy

At necropsy the commonly recorded features are pleural adhesions, cartilaginous pleura, large melanotic glands, lung tissue hard and inelastic, enlarged air cells and heart hypertrophied but otherwise unaltered.

Two distinct groups of lung changes were clearly recognized approximating closely to simple dust reticulation of coal miners and complicated pneumoconiosis. The former is represented by these excerpts :

"The pulmonary tissue was very black, and afforded the black colouring matter with great facility when cut down and pressed in water. It appeared, however, sound and to have suffered no change of structure."

and in another case :

"Black infiltration of the lung was discovered in what I presume to be its early stage—that in which the substance of the lung, though charged with black matter, is still crepitous and respirable."

The following accords with complicated pneumoconiosis possibly of silico-anthraccotic type :

"On removing the two lungs from the chest, they were seen to present, over their whole surface, a general deep or dark blue colour. The surfaces of both lungs were very rugged and uneven, from irregular superficial puckerings at some parts, and small and apparently emphysematous elevations at others. Both their lower lobes were extremely emphysematous, some of the emphysematous cells being as large as walnuts. . . . The upper lobes of the two lungs, and some portions of the lower lobes, though considerably oedematous, were crepitant, elastic, and light enough to float in water. Several portions of greater or less extent in the lower lobes were converted into a compact, indurated but always deep black structure, and in the upper part of the lower lobe of the left lung, these solidified portions were very friable, and had broken down into irregular excavations, traversed by shreds or bands of the disintegrated pulmonary structure, and filled with a substance like thick liquid blacking, or a very strong solution of china-ink. Throughout the whole substance of both lungs, except at the points where the structure of the organ was generally solidified, a number of small, firm, scattered knots or granules, like miliary tubercles, could be felt and seen."

Several of the other cases are consistent with pneumoconiosis accompanied by tuberculosis.

George Hogg, aged 40 years at the date of his death, had been employed for several years "as a coal-setter, or in removing the strata of sandstone, and the beds and veins of secondary trap and other

rocks of the mine that impeded the free working of the coal seam. Some of the coal-setters that worked in the same mines as himself, have, to his knowledge, died after labouring under catarrh of a more or less chronic character with black expectoration".

The post-mortem findings suggest massive silicosis and the minute accuracy of the description is impressive.

"On raising the sternum the lungs were seen projecting forwards, and appeared to fill completely the cavities of the chest."

"Judging from the strength of these pleuritic adhesions, and from the difficulty with which they were torn, they appeared to be of an old date. . . .

"Their external surface, particularly that of the left lung, felt in numerous points rough and a little elevated by defined deposits of a solid matter beneath the pleura, in the form of compact masses of nodules, roundish, oblong, variously irregular in their figure, at some points isolated, and at others more or less agglomerated, and varying from the size of a hempseed to that of a cherry-stone or larger. . . .

"At one part of the surface of the upper lobe of the left lung, and immediately connected with and covered by a portion of corresponding, thickened and almost cartilaginous pleura, the substance of the lung, for about an inch in extent and a quarter or half an inch in breadth and depth, seemed transformed into a mass, the section of which very much resembled, both in point of density and colour, the section of a piece of compact black caoutchouc."

Varieties of Pneumoconiosis

Dr. Dewar of Dunfermline clearly distinguished between varieties of pneumoconiosis, their aetiology, and significance :

"You will please observe the distinction between colliers and stone-workers. The former are employed merely at the coal-wall, and use only picks and wedges at their work ; while the stone-workers are occupied, in whole or in part, in removing the freestone and other rubbish which separate the different layers of coal. In these latter operations, the aid of gunpowder is constantly required, and the workmen, from the very imperfect state of the ventilation, are frequently enveloped in dense smoke. The persons who are exposed to this noxious atmosphere are, so far as my experience goes, the victims of this most fatal species of disease in the lungs, viz. consumption with black spitting."

Differences in Risks

Dr. Steele adds his testimony in support, and adds further to our knowledge of specific conditions in different mines which magnified the risk.

"In the mid-Lothian coal-field the edge-seams are considered to be in a much greater degree injurious than the flat. This is owing chiefly to three circumstances :—1st. In the edge seams the strata are not so much impregnated with water. 2nd. The cutting process by the pick of the miner is carried on more upon a line with his own face, and hence more dust is emitted and inhaled. But the principal reason is,

that the stone contains some poisonous matter which is probably of a metallic nature, as the workman complains of its exciting a styptic and metallic taste in the mouth. A mine was carried across the strata in the Niddry estate, the finishing of which required a number of years. Six or eight of the miners employed in it died; several were obliged to leave it, and only one of those who commenced it was able to work in it throughout and lived to see it completed. There was a particular stone in this mine, which was repeatedly met with, and to which the miners gave the name of arsenic, which was found highly pestiferous; its exact nature I am not acquainted with. In a stone-mine seen some years ago in the Newbattle field, a great many men died, the average length of time each of the miners employed in it lived, being about two years. The mortality was ascribed to the nature of the stone."

Dr. Stevenson of Gilmerton added further valuable comments. He considered that the evil arose from the species of rock through which the mines are driven, particularly sandstone, and not from the mere operations of mining alone.

Association with Other Diseases

As to the effect on health and longevity, Dr. Steele observed:

"Those who restrict themselves to the working of coal are not peculiarly liable to pulmonary complaints, and they are as long-lived and as healthy as any class of labourers whatever. The temperature of the place in which they work is almost always warm and equable; they suffer little from any inflammatory complaint excepting rheumatism, and tubercular phthisis is among them a rare disease."

Dr. Steele of Midlothian summarizes these aspects admirably:

"The period of life at which the disease occurs must vary according to the length of time the individual has been exposed to the exciting cause and to natural difference of constitution; and it must depend also on the nature of the minerals in which the mining operations are conducted. I have often seen it prove fatal about the age of from fifty to fifty-five."

Generally the disease once contracted was recognized to be incurable, but Steele records that if the workman "be under forty years of age and if he take care of himself, he may still be restored to the enjoyment, for a time at least, of tolerable health; but if towards fifty there is no hope for him".

This may be due to the fact that the aid of the doctor is sought too late.

And here is a description of the last phase of the illness.

"He is awake with sometimes an intense feeling of suffocation; his lips and face become livid, he throws his body forwards and grasps his knees with his hands, that being the only attitude in which respiration can be carried on."

Apparently affected men, who though no longer able to work at the coal-face, were able to do other work. Thus John Cowan, aged 58 years, a coal miner from his boyhood, had symptoms of chest disease for seven years. Finally "he was compelled by the state of his complaints to abandon working in the mine, but he continued to do light work above ground until rendered totally unfit".

Others reflect a problem all too familiar today:

"The man determines to give up stone-working, and does so for a time but the inducement of a higher rate of wages again tempts him to his destruction."

Geographical Distribution of the Disease

As to incidence of the disease throughout the mining areas there are no statistics but Steele represents the experience of not a few doctors.

"It would afford me much gratification if any means could be devised as regards either prevention or remedy, whereby might be lessened the evils of a disease, the ravages of which, upon the most robust constitutions, I have every day cause to deplore."

The Report of the Commission on Mines (1842) leaves no reason for doubt as to the general prevalence of the disease throughout Great Britain. Evidence by doctors practising in every mining community reveals the unusually high morbidity and mortality from chronic pulmonary diseases among miners, and the reports by Scottish doctors are particularly definite.

Makellar (1845), who practised in the coal-mining district of Haddingtonshire, was the next to present his experiences of the disease, and this is of particular interest as it reveals his reaction to the Report of the Commission on Mines. He is in no doubt as to the cause of the disease.

"The disease is due to carbon, which has been conveyed into the minute pulmonary ramifications, in various forms, during inspiration; and which while lodged in these tissues, produces irritation, terminating in chronic ulcerative action of the parenchymatous substance. The very minute bronchial ramifications first become impacted with carbon, and consequently impervious to air; by gradual accumulation, this impacted mass assumes a rather consistent form, mechanically compressing and obliterating the air-cells, irritating the surrounding substance, and promoting the progressive extension of the morbid action, till the whole lobe is infiltrated with carbonaceous matter, which, sooner or later, ends in ulceration and general disorganisation of the part."

Originally whale oil was used for burning in the miners' cap-lamps, but about 1815 linseed oil was substituted on grounds of economy and "many old miners date the greater prevalence of black spit to the introduction of linseed oil" which was much more sooty.

Makellar is the first effectively to approach the problem of prevention:

"The coal-miners—those on whose behalf I would now solicit the intervention of science—are most valuable in their place, and their exhausting labours promote, in no small degree, our domestic comforts."

"It is to be regretted, however, that his Lordship (Lord Ashley) did not embody in his measure, provisions enforcing the free ventilation of mines under government inspection, for nothing would tend more to improve the health of those employed in them."

The interest of doctors continued but with a changing emphasis. In 1851 William Calder presented a case to the Edinburgh Clinical Club. Discussing the occurrence of the disease he remarks :

"Some have supposed that tubercular phthisis is first set up, and that the carbonaceous deposit is then insinuated among the textures and ulcerations."

This conclusion is simple and practical.

"The disease, once established, does not admit of cure by art. The only means of preventing the disease seems to consist in ventilating the mines where colliers work, or adopting means of carrying off the fumes to which the moulders of iron and copper are exposed. Such prophylactic measures are equally called for, whatever theory of the nature of the disorder shall ultimately prove to be correct."

Six years later Cox (1857), writing of the diseases of colliers in South Lancashire, propounds the importance of the preventive idea :

"The prevention of disease is fully as reliable a testimony of professional skill and scientific knowledge as its treatment ; whilst it is generally considered to constitute a surer evidence of the possession of that disinterested and noble philanthropy which should ever characterise the disciples of physic."

And, moreover, disease involves the whole man, in his body and in his mind.

"By the dispensations of the All-Wise, the laws of our *physical* being, and those by the operation of which our *moral* nature is regulated, are so nicely balanced, so admirably linked together, that any infringement of the one is speedily productive of a baneful effect in the proper observance of the other ; and the equilibrium once being destroyed, the reaction of evil from each to each goes on, multiplying mischief, until the body and the mind are alike tainted and corrupt."

As a means of amelioration he suggests the establishment of mechanics' institutes and adult education, but of primary importance he considers the establishment of baths and wash-houses in the immediate vicinity of the coal pits, and the erection of improved dwellings with a good water supply for the habitation of the operatives.

Discussion of the precise cause of the disease continued, and so renowned a pathologist as Virchow (1858), following microscopic examination of coal from various countries, submitted that coal is never really black but brown and he therefore concluded :

"This distinction is so marked and constant, that we cannot admit the inhalation of particles of coal dust as the source of the pigmentation."

He is even more explicit in rejecting inhaled dust as the causative agent ; the condition, he says is "due to extravasation of blood and subsequent transformation of haematin and not with an absorption and deposit of carbonaceous matters inhaled into the lungs."

Definition of "dust" is still a matter of considerable controversy, so, in passing, it may be justifiable to note the words of Cox, "solid mechanical impurities . . . floating in a minute state of division", and again "impalpable powder".

By many the soot from oil lamps and the smoke of tallow candles continued to be regarded as contributory. In 1864 at a meeting of the Medico-Chirurgical Society of Edinburgh, Sanders (1864) presented a preparation of material expectorated by a patient and for comparison a micro-specimen of Dalkeith coal. They were identical. Comment is made that :

"This observation was of some importance in regard to the question still undecided whether the black matter in the coal-miners' melanotic lung was due to coal, or only to a deposit of pure carbon."

Meanwhile Thomson (1858) reviewing the problem remarked :

"I cannot help thinking that medical inspectors should, long ere this have been appointed to co-operate with mining engineers, in order to apply the most enlightened rules of hygiene for the safety and health of this numerous and important class of workpeople. Had this been the case, I am satisfied that the true cause or causes of their diseases would, ere now, have been much palliated or prevented."

So he makes the following recommendations :

"(1) I would insist by conciliatory or repressive measures upon the substitution of tallow for oil. (2) There ought to be a Medical Inspector of Mines, and (3) we want due regulation and restriction of the hours of labour".

During the next few years Sir John Simon, Medical Officer of the Privy Council, deputed Dr. Greenhow, a member of his staff, to enquire into the excessive mortality from lung diseases, which had been shown, by official statistics, to occur in certain mining districts throughout England and Wales. Greenhow visited the various areas, where he consulted with employers and workmen. His findings were duly recorded in reports in 1860 and 1861. In the second report he states :

"Some miners retain their health till an advanced period of life, but the greater number suffer, more or less, from asthmatical symptoms before attaining the age of 50, and many break down and are disabled at from 40 to 50 years of age."

A collier, who had previously worked in Cumberland, and interviewed at Wolverhampton, was of opinion that asthma was more prevalent among colliers in south Staffordshire than in Cumberland, and he ascribed the difference to less perfect ventilation of the south Staffordshire collieries.

Another very intelligent miner in the same area confirmed this experience, but emphasized that the disease depended on the constitution of the men and whether or not they habitually work in ill-ventilated places, or in mines that give out much "damp".

This last observation is of considerable interest in relation to the "rank of coal" hypothesis advanced by Hart and Aslett (1943) to explain the widely divergent incidence of pneumoconiosis between the anthracite and bituminous areas of South Wales.

At Merthyr Tydvil and Abergavenny, Greenhow obtained similar evidence and he finally sums up:

"In reference to this disease it seems quite certain from the evidence adduced, that it is much less prevalent than formerly; a result, as was distinctly stated by many witnesses, of the official inspection of coal-mines."

In 1866 Warburton Begbie comprehensively reviewed the current knowledge of anthracosis or coal miners' phthisis. He describes anthracosis as "a pulmonary disease . . . specially although not exclusively met with in coal mines, which now threatens to become very rare in its occurrence; there are indeed indications of its happily altogether disappearing". Commenting on the attitude of the men themselves he indicates that they ignore black spit as part of their occupation and not necessarily unhealthful.

A relevant comment from a non-medical source appears in the annual report of Mr. Leonard Brough, H.M. Inspector of Mines for South Wales and Monmouth (1871):

"Abundant ventilating power, plenty of room for air in motion throughout the pit, attention to the state of the atmosphere, good officers and strict discipline; these are the arcana of safety underground, if indeed there are any secrets in the matter, which I very much doubt, for it is only a question of money after all."

Probably he was primarily concerned with the prevention of underground explosions but his observations are obviously pertinent to general health conditions.

The Scottish story of miners' anthracosis was resumed in 1875 by Dr. William Sneddon who practised at Beith in the Ayrshire coalfield. He records that the air of the mines had been considerably improved and as a result "the disease is somewhat rare now, at least in its acute form".

Nowadays the payment of danger or dirty money is a well-established incentive practice in many occupations and industries, so it is interesting to learn that then as now

"There are some men so short-sighted that they are known to work in the worst place in the mine for a larger rate of wages."

It is abundantly clear that Sneddon and his fellow practitioners were concerned to discover how the effects of the disease might be retarded and mitigated, how men in serious stations in the mine might be transferred to less dusty places. Sneddon expresses his views:

"In the majority of works that I know of, there are special men for each of the employments mentioned. It would be better if the miner, instead of always being confined in his small, dusty, ill-ventilated place, would also assist in drawing his coals, etc., from the 'face' to the bottom of the pit, where he would be in a clearer and better air occasionally."

This plan is not so very much different from our modern recommendations of work "in approved dust conditions".

Reference to the diminishing prevalence of the disease continued. At the annual meeting of the British Medical Association held at Sheffield in August, 1876, Dr. Edwin Chadwick presided over a symposium on industrial diseases. Dr. W. T. Gairdner, Regius Professor of Medicine in the University of Glasgow, had been invited to present a paper on "collier's black spit". This he was unable to do for as he explained:

"He had been unable to obtain sufficient information on the subject, and this he ascribed to the fact that this special form of pathological lesion had so much diminished of later years, in consequence of improved sanitary precautions, as to be almost quite extinct."

The next contribution, by reason of the particular qualification of its author, is of unusual interest.

In the year 1876 Dr. T. G. Nasmyth started practice in the colliery village, Hill of Beath, Fife. Not only was he a physician but he was also a Doctor of Science of Edinburgh University, and he was particularly interested in the study of the air of mines. He records that:

"In talking with miners on the subject, they have told me that about twenty years ago sometimes the air was so bad that, if the lamp were unaided, it would not burn, but by constant attention it might be made to give out a feeble light, and it was frequently the duty of boys when too young or too small for harder work to trim the lamps, and keep them burning for their fathers or seniors. This is a rude test, but at the same time impresses one with the idea, that the air must have been very bad."

In support he cites the observations made by Angus Smith in 1863, who by the examination of 339 specimens of air from coal mines found 0.785% carbonic acid. He concludes:

"The point seems to be abundantly proved that, twenty-five years ago, at any rate, the air of mines was bad, and the effect on the health of the miners was correspondingly bad."

Nasmyth's experience extending over the 12 years, 1876-1887, had been marked by great improvements and he sums up :

"Twenty years ago air was very bad in mines ; ventilation was almost unknown, and the hours were very long. Nowadays the air is generally good ; ventilation is efficiently carried on, and the hours of work are short. The miner works hard whilst at his work, but he has short hours and many holidays. In the tables of statistics, I have shown that phthisis, contrary to general opinion, is not a common disease amongst miners, and my own everyday experience for ten years in a large mining population supports these tables. In fact, I know of no disease peculiar to miners, or any disease in excess existing among miners. I have also consulted many other medical men practising among colliers, and their opinion coincides with my own. In conclusion, I have to state, as my belief, that the conditions connected with miners' occupation are as favourable to health as those in the occupations of any other workman, and this opinion is borne out by the vital statistics quoted."

It is pertinent to remark, in passing, that the discovery of the tubercle bacillus by Koch in 1882 had enabled medical men to distinguish between phthisis and tubercular phthisis, and that Sneddon in 1875 had recorded that the mean age at death of miners in his practice was 43.1 years, which compared favourably with other occupations.

So it would appear that an end had been reached ; the lung diseases of coal miners variously denominated as black spit, black infiltration of the lungs, spurious melanosis, anthracosis, phthisis melanotika, and pneumoconiosis anthracosica had, for all practical purposes, ceased to exist as a medical problem. This happy state had been achieved in 50 years, 1825 to 1875, by improved ventilation and improved sanitary conditions in coal mines, together with shorter working hours. In that period doctors by their assiduous studies *post-mortem* had accurately described and distinguished the various pathological changes in the lungs and the associated effects on other organs. These lesions had, in turn, been precisely correlated with the clinical manifes-

tations. After considerable controversy, they were almost unanimously agreed that the disease involved some constitutional factor but primarily arose from the inhalation of mine dust ; that simple coal dust was comparatively harmless and that stone dust was the really noxious factor. In relation to coal dust tubercular phthisis was rare, whereas in relation to stone dust it was common. During the early years when the disease was prevalent in colliery villages, the doctors had not failed to emphasize the social and economic problems of the disabled workmen and they had recommended practical means of mitigating the disease and its consequences.

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